gitudinal sections. If my determination is correct, it represents (not merely according to transcendental homological signification, but as a simple question of plain anatomical observation) the whole of the great transverse commissure, or corpus callosum of the lower placental mammals, only in somewhat reduced proportions, and with relations somewhat modified by the peculiar form of the inner cerebral wall.

There is consequently no superadded structure in the brain of the latter group.

To the imputation, twice repeated, of having "obtained" or "derived" the notions and ideas contained in my paper from Professor Owen's writings, no direct reply is necessary. The communication which I presented to the Society is the result of repeated original observations and dissections, made at various periods, extending over more than three years. The descriptions are all verified by drawings and preparations.

That their publication (if they should be so honoured) may advance in some slight degree our knowledge of a difficult and obscure, yet important branch of anatomy, is all that I venture to hope. That they are entirely free from errors, or that they may not, at some future time, be superseded by the researches of abler investigators, I do not presume to believe.

II. "On the Size of Pins for connecting Flat Links in the Chains of Suspension Bridges." By Sir CHARLES FOX. Communicated by the President. Received March 2, 1865.

In the construction of chains of this kind, it is of the highest importance that the pins, which pass through and connect together the links of which the chains are composed, should be of the right size, inasmuch as their being too small, as compared with the links through which they pass, renders ineffective a portion of the iron contained in the latter, which then exists only as a useless load to be carried by such links; while at the same time, if the pins and heads of the links be too large, they become uselessly cumbersome and expensive.

Careful examination and experiments made upon a large scale (which will be explained hereafter) have brought out facts by which a simple rule has been arrived at—a rule that may safely be adopted as a guide in deciding upon the relative sizes of these two parts.

On this rule mainly depends the economical use of iron in the construction of such chains.

In this paper the term chains for suspension bridges implies such as are usually employed, and are composed of several flat bars of equal thickness throughout, placed side by side, but having their ends swelled edgeways so as to form what are technically termed heads, and which are coupled together by pins passing through holes in such heads, as shown in figs. 5 & 6 in the accompanying drawing.

In deciding upon the size of the pins, it has often been assumed, as

a close approximation, that, as about the same force is required for shearing as for breaking wrought iron by extension, it would be necessary to give the pin a cross section equal to the sectional area of the smallest portion of the link only. The fact of the possibility of links being torn and destroyed by the pin being too small to present the necessary bearing surface, although quite large enough to resist the calculated shearing force brought to bear upon it by the links, seems hitherto not to have attracted notice; but as the strength of a chain depends upon the proper extent of surface being offered by the pins of the links to pull against, such a mode as the one described has been proved by experiment to be altogether fallacious. For by this mode of estimating, the size of a pin passing through links 10 inches wide and of uniform thickness (that is, not having the head thicker than the body of the link) would be something less than $3\frac{1}{2}$ inches in diameter, whereas (as will presently be shown), in order to get the whole benefit from such a link, the pin must be somewhat more in diameter than 6 inches, and for the following reasons.

In wrought iron the initial forces necessary to extend, or diminish by compression, the length of a bar are practically the same; and hence it arises that unless the surface of the pin on which the semicylindrical surface of the hole in the link bears is as great as the smallest cross section of the link itself, the head will be torn by the pin; and since to provide this necessary surface it is essential to have a pin of much larger size, the question of its ability to resist the operation of shearing never arises, and the whole subject resolves itself into one of bearing surface.

If the pin be too small, the first result on the application of a heavy pull on the chain will be to alter the position of the hole through which it passes, and also to change it from a circular into a pear-shaped form (*vide* fig. 2), in which operation the portions (A A, figs. 2 & 3) of the metal in the bearing upon the pin become thickened in the effort to increase its bearing surface to the extent required. But while this is going on, the metal around the other portions (B B, figs. 2 & 3) of the hole will be thinned by being stretched, until at last, unable to bear the undue strains thus brought upon it, its thin edge begins to tear, and will, by the continuance of the same strain, undoubtedly go on to do so until the head of the link be broken (or, rather, torn) through, no matter how large the head may be; for it has been proved by experiment that by increasing the size of the head, without adding to its thickness (which, from the additional room it would occupy in the width of the bridge, is quite inadmissible), no additional strength is obtained.

Acting upon the principle above described, most engineers have made the pins of their chains far too small, whereby much money has been wasted in making the links of a size, and consequently of a strength, of which it was, through the smallness of the pins, impossible to obtain the full benefit. Indeed to such an extent has this been carried, that in one of the most noted suspension bridges hitherto constructed, a very large sum

has been thrown away upon what is worse than wasted material, inasmuch as that material, remaining as load only, has to be carried by the chains, and correspondingly weakens the structure.

I am also acquainted with a very recently constructed suspension bridge in which some of the links, which are 10 inches wide, have the holes in their heads but 2 inches, instead of $6\frac{1}{2}$ inches, in which case more than two-thirds of the iron in the links is useless.

The first time my attention was seriously called to this important subject was when Mr. Vignoles entrusted my late firm of Fox, Henderson, and Co., with the manufacture of the chains of the great suspension bridge for carrying a military road over the Dnieper, at Kieff, which was constructed by him for the Russian Government.

As the chains for this bridge weighed upwards of 1600 tons, upon which the expense of transport was very heavy, they having to be shipped to Odessa, and thence carted over very bad roads for upwards of 300 miles to Kieff, it was considered of the first importance to ascertain whether or not they were well proportioned; and accordingly a proving-machine was specially prepared, of power sufficient to pull into two any link intended to be used on this bridge.

These links, as shown in the drawing attached to the contract (see fig. 1), were, for convenience of transit, but 12 feet long from centre to centre of pin-holes, $10\frac{1}{4}''$ wide by $1''$ thick in their body or smallest part, with a head at each end also $1''$ thick, swelled out to $16\frac{1}{2}''$ in width, so as to allow of holes for receiving pins $4\frac{1}{2}''$ in diameter. The cross-sectional area of these pins was 15·9 inches, or rather more than 50 per cent. in excess of the cross-sectional area of the link at its smallest part.

According to the usual mode of ascertaining the size of these pins, by making them of such dimensions as to resist the force required to shear them, they possessed upwards of a third more section than was thus shown to be necessary. Still, in practice, a pin of this size proved altogether disproportionate to the size of the links, and required to be increased from $4\frac{1}{2}''$ to $6\frac{1}{2}''$ diameter before it was possible to break a link in its body or narrowest part—fracture in every previous case taking place at the hole, and through the widest part of the head, as shown in fig. 2.

The iron in the links for this bridge was of a very high quality, and was manufactured by Messrs. Thorneycroft and Co., from a mixture of Indian and other approved pig-iron, and required a tensile strain of about 27 tons per sectional inch to break it; so that taking the narrowest part at, say 10 inches, a strain of 270 tons ought (had the size of the pin been in proper proportion) to have been required to pull it into two; instead of which, so long as the pins were but $4\frac{1}{2}$ inches in diameter, the head tore across (as shown at fig. 2) at its widest part with about 180 tons, or two-thirds only of the strain desired and provided for as far as the size of the body of the links was concerned.

This unexpected result led to the belief that the size of the heads was

insufficient; and accordingly a few experimental links were prepared with their heads 2 inches wider than before (as shown in fig. 4); but these nevertheless were found to require no additional force to tear asunder; hence it became obvious that fracture arose from some cause not yet ascertained.

As has already been stated, the rupture took place across the widest part of the head (C C, fig. 2); but on attempting to adjust the piece broken off to the position it originally occupied in the link, it was observed that, while the fractured surfaces came in contact at the outside of the head, they were a considerable distance apart at the edge of the pin-hole (see fig. 2).

This at once proved that during the application of the tension, which at last ended in producing fracture, the various portions of the head had been subject to very unequal strains; and upon careful examination, the rationale of this fracture became apparent from the consideration that the hole, which originally was round, had become pear-shaped (see fig. 2), having altered its position, and that the iron of the link which, during the application of the load, bore upon the pin, and was consequently in a state of compression, had become considerably thickened in consequence, as was now evident, of an effort to obtain a greater bearing surface (see A, figs. 2 & 3), while the other portion of the iron around the pinhole, being subject to tension, had been so weakened and thinned by being stretched, as to cause a tearing action to take place, which, having once commenced, would obviously, by the continuance of the same strain, rend through the entire head, no matter what its width might be.

From this it was clear that any increase of size in the head (unless by thickening, which, as I have before stated, is inadmissible) was of no avail; and it was now that the principle which forms the subject of this paper became manifest—viz., that there was a certain area of the semicylindrical surface of the hole having a bearing on the pin proportionate to the transverse section of the body or narrowest part of a link, and quite essential to its having equal strength in all its parts; and that any departure from this proportion could not fail to bring about either waste of iron in the body of the links, if the pin were of insufficient size to offer proper bearing surface, or waste of metal in the heads of the links and in the pins, if the latter were larger than necessary for obtaining this fixed proportion of areas.

Having arrived at this point, a link, similar in all respects to the previous one, with holes $4\frac{1}{2}$ inches in diameter, and which broke across the head with 180 tons, was taken, and its holes enlarged to 6 inches, but without increasing the width of the head, which still remained $16\frac{1}{2}$ inches; so that the only difference was the removal of an annular piece $\frac{3}{4}$ inch in width from the hole, and so making it 6 inches instead of $4\frac{1}{2}$ inches in diameter, thereby actually diminishing the quantity of iron in the head to this extent —when it was most interesting to discover that by this slight alteration, by which the semicylindrical surface bearing on the pin had been increased

from 7·0 to 9·4 sectional inches, the power of the link to resist tension had increased in about the like proportion, having rendered a force of nearly 240 tons necessary to produce fracture.

Fig. 1.
Fig. 2.
Fig. 3
Fig. 4.
Fig. 5.
Fig. 6.

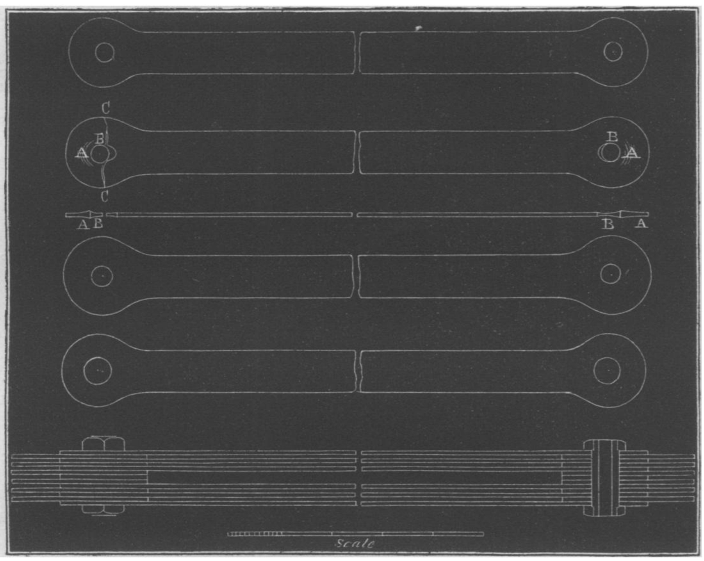

Fig. 1. Link for Kieff Bridge. Depth of head $16\frac{1}{2}$ in., of centre $10\frac{1}{4}$ in., diameter of hole $4\frac{1}{2}$ in.
Fig. 2. Elevation showing result of proof.
Fig. 3. Section through centre, showing result of proof.
Fig. 4. Experimental link, with wider head. Depth of head $18\frac{1}{2}$ in., diameter of hole $4\frac{1}{2}$ in.
Fig. 5. Link with properly proportioned hole for pin. Depth of head $17\frac{1}{2}$ in., diameter of hole $6\frac{1}{2}$ in.
Fig. 6. Plan of chain, and section of pin and links.

From subsequent experience, it has become evident that had the pins of these chains been increased to $6\frac{1}{2}''$ diameters, giving a bearing surface of 10·2 square inches, the proper proportion between them and the body of the links would have been very nearly arrived at, while with those of only $6''$ diameter about an inch of the body of the links was wasted.

The practical result arrived at by the many experiments made on this very interesting subject is simply that, with a view to obtaining the full efficiency of a link, the area of its semicylindrical surface bearing on the pin must be a little more than equal to the smallest transverse sectional area of its body; and as this cannot, for the reasons stated, be obtained by increased thickness of the head, it can only be secured by giving a sufficient diameter to the pins.

That as the rule for arriving at the proper size of pin proportionate to

the body of a link may be as simple and easy to remember as possible, and bearing in mind that from circumstances connected with its manufacture the iron in the head of a link is perhaps never quite so well able to bear strain as that in the body, I think it desirable to have the size of the hole a little in excess, and accordingly for a 10″ link I would make the pin $6\frac{2}{3}$″ in diameter instead of $6\frac{1}{2}$″, that dimension being exactly two-thirds of the width of the body, which proportion may be taken to apply to every case.

As the strain upon the iron in the heads of a link is less direct than in its body, I think it right to have the sum of the widths of the iron on the two sides of the hole 10 per cent. greater than that of the body itself (see fig. 5).

As the pins, if solid, would be of a much larger section than is necessary to resist the effect of shearing, there would accrue some convenience, and a considerable saving in weight would be effected, by having them made hollow and of steel.

In conclusion, I would remark that my object in writing this paper has been, first, to call attention to the fact that a link is far more likely to be torn by the pin being too small, than a pin to be sheared by a link; and secondly, to try to establish a simple rule by which their proper comparative sizes may always be arrived at; and I have been induced to investigate this very important subject from having generally found in existing suspension-bridge chains a wide departure from what is right in this respect, in having the pins far too small.

III. "On the Influence of Quantity of Matter over Chemical Affinity, as shown in the formation of certain Double Chlorides and Oxalates." By George Rainey, M.R.C.S., Lecturer on Microscopical Anatomy, and Demonstrator of Surgical Anatomy at St. Thomas's Hospital. Communicated by Dr. Gladstone. Received March 2, 1865.

The simple fact that quantity of matter has the effect of influencing chemical affinity is so well known and so generally admitted, that any special remark upon it would be superfluous; I shall therefore in this communication chiefly confine my observations to the compounds above named, by which this effect will be shown to be strikingly exemplified, offering such explanations and remarks thereon as the nature of the facts may seem to demand.

The results of nearly all the experiments mentioned in this paper were first arrived at by operating upon very minute quantities of material, and by observing under the microscope the changes that take place; but afterwards the same products were obtained on the large scale by appropriate processes, and in quantities sufficiently large to admit of being analyzed quantitatively, and of having their formulæ accurately determined. I shall therefore commence by giving an account of the processes by which the